Conservative Management of Retained Cardiac Missiles: Case Report and Literature Review

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Intracardiac foreign bodies may be caused by direct penetrating trauma, embolization from injury to another area of the body, or iatrogenically from fragments of intravascular access devices. Penetrating cardiac trauma commonly presents with a hemodynamically unstable patient necessitating emergent life-saving procedures. Missile embolization to the heart can occur after injury to systemic and pulmonary veins. Central venous access devices may fracture after placement and embolize. Especially in the setting of penetrating cardiac trauma, these intracardiac foreign bodies require expeditious removal. Limited data exist regarding the conservative management of intracardiac material after trauma. We present the case of a 42-year-old male soldier injured in a mortar blast in Iraq who suffered multiple injuries to include a right hemopneumothorax and soft tissue injuries to the chest and both lower extremities that was found to have a 2-cm by 2-mm intracardiac metal fragment. Additional imaging revealed a metallic fragment localized to the interatrial septum. The patient suffered no adverse sequelae from nonoperative management. A review of the world literature regarding the subject of posttraumatic retained cardiac missiles (RCMs) is also included to help future surgeons in the management of this rare entity. (J Surg 66:228-235. © 2009 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

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INTRODUCTION

Patients who suffer cardiac trauma typically present in extremis and require aggressive life-saving maneuvers such as resuscitative thoracotomy or median sternotomy to identify and manage associated injuries. An uncommon situation exists when a patient suffers a penetrating injury that results in a hemodynamically normal patient with foreign material deep to the pericardial sac. Retained cardiac missiles (RCMs) have been defined as bullets, fragments, pellets, and other material that are found deep to the pericardial sac after trauma.[1] RCMs may be the result of direct penetration of the pericardium or via embolization after injury of peripheral or pulmonary vessels. Because of the rarity of this injury, guidelines regarding the proper management of RCMs are nonexistent. Symbas et al[1] published a literature review and summary of their personal experience with this fascinating problem in 1990 that concluded that cases should be approached on an individualized basis according to the patient presentation and clinical course, the characteristics of the missile, and the approach that conservative, nonoperative management is tolerated well in many cases. We present a case of successful nonoperative management of an RCM diagnosed in a patient 1 week after a mortar blast injury and provide an updated review of the literature to assist future surgeons faced with this challenging entity.

A 42-year-old white male suffered multiple fragment injuries secondary to a mortar explosion while deployed during Operation Iraqi Freedom. Initially, he presented hemodynamically stable with a chest radiograph demonstrating a right hemopneumothorax and multiple soft tissue injuries to his chest and both lower extremities. A right tube thoracostomy was performed to treat the hemopneumothorax. A negative laparotomy was performed after computed tomography of the abdomen and pelvis revealed evidence of free intra-abdominal air. He recovered from his initial injuries and was evacuated to Dwight D. Eisenhower Army Medical Center. A review of computed tomography of the chest obtained for persistent oxygen requirement and fevers on posttrauma day 7 revealed an intracardiac metallic fragment in the vicinity of the interatrial septum (Fig. 1). Additional imaging was obtained, including transthoracic and trans-

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FIGURE 1. Axial computed tomography image of intracardiac metallic fragment.

esophageal echocardiography, cardiac fluoroscopy without contrast, and gated 3-dimensional computed tomography of the heart. Because of significant scatter, the exact location of the fragment could not be determined by imaging; however, it was concluded to be embedded in the muscle of the interatrial septum within the right atrium. The patient was systemically anticoagulated for 3 months and has had follow-up echocardiography and fluoroscopy demonstrating no change in the position of the metal fragment. He remains asymptomatic and has returned to duty.

LITERATURE REVIEW

We reviewed the world literature regarding the subject of RCMs. A review by Symbas et al[1] in 1990 outlines historical cases of retained cardiac missiles as well as the author's personal experience with this process at Grady Memorial Hospital. We conducted a MEDLINE review of the literature beginning in 1990 until the present for cases of RCMs. The search terms included cardiac missile, cardiac foreign body, retained cardiac missile, and retained cardiac foreign body. All related articles were also reviewed for pertinence to our report. We included bullets, pellets, fragments, nail-gun injuries with completely intrathoracic nails, and other high-velocity missiles that came to rest deep to the pericardial sac by means of direct penetration or embolization. We excluded reports of patients with cardiac trauma requiring immediate intervention as well as patients with embolized needles, glass, and other low-velocity intracardiac material. We found a total of 97 cases of RCM from 1990 to the present. A total of 52 patients were initially managed operatively.[2-43] Operatively managed patients were predominantly male (n = 44) and had a mean age of 40 years (range, 5–67 years). The intracardiac location of the missile was a result of direct entry in 36 patients, via embolization in 15, and not reported in 1. Location within the heart showed right heart location to be most common (n = 25), followed by left heart (n = 10), pericardial (n = 8), intramyocardial with no dominant side specified (n = 6), within the right coronary artery (RCA) (n = 1), multiple sites (n = 1), and no site specified (n = 1). The indications listed for operative intervention included prophylaxis or unknown (n = 20), irregular fragment shape (n = 11), tamponade (n = 9), missile passage through contaminated site (n = 4), prevention of additional embolization of mobile fragment (n = 3), wandering intrapericardial location (n = 2), ease of retrieval during sternotomy for other indications (n = 2), and fevers (n = 1). Only 1 patient (2%) initially treated operatively for a retained cardiac missile was reported to have developed a complication.[38] Nolke[38] reported a case of a 37-year-old man suffering a nail-gun injury to the left ventricle who required left thoracotomy with extraction. The patient went on to develop pericarditis that was successfully managed with enteral anti-inflammatory agents. Our literature review found 45 patients that were initially managed nonoperatively.[44-80] Similar to operatively managed patients, nonoperative patients were mostly male (n = 37) with a mean age of 31 years (range, 3–78 years). Right heart location (n = 16) was the most common intracardiac site for missiles to be found, followed by left heart (n = 8), pericardial (n = 8), intramyocardial with no dominant side specified (n = 7), RCA (n = 4), and no site specified (n = 2). The complication rate for the nonoperative arm was 33% (n = 15). Table 1 summarizes the characteristics and management of the complications of nonoperative management of RCM since 1990. Patients with RCM in the pericardium or embolizing to the RCA suffered a complication rate of 75% (Table 2). Complications of nonoperative management included myocardial infarction or ischemia,[46,64,67,74] dysrhythmia,[35,55,66] pericardial complications[45,47,59] (effusion or pericarditis), valvular dysfunction,[78,80] intracardiac shunt,[44,65] and lead toxicity requiring no intervention.[61] Ultimately, 60% (n = 9/15) of nonoperatively managed patients required operative management because of their complication. The length of time postinjury until the presentation of a complication in the nonoperative group ranged from 12 hours to 60 years.

DISCUSSION

Cardiac missiles are defined as bullets, pellets, or fragments secondary to gunshot/shotgun injuries, mortars, grenades, mines, or other explosives.[1] Entrance into the pericardial sac, myocardium, or cardiac chambers may be caused by direct penetration. Embolization from a systemic or pulmonary vascular injury may lead to retained cardiac missiles within a chamber. Although patients sustaining penetrating cardiac trauma may present in extremis, reports exist of patients with RCMs. Controversy persists in the trauma literature about the appropriate management of asymptomatic RCM. A study of 100 patients in

TABLE 1. 1990–Present Complications of Nonoperative Treatment of Retained Cardiac Missiles

Author (Reference)	Location	Complication	Time to Complication	Treatment
Nobre et al[44]	LV	Traumatic VSD	<24 hours	None
Monsuez et al[45]	Pericardium	Pericarditis	45 years	None, refused operation, successful treatment with diuresis
Hopkins et al[46]	RCA	Inferior myocardial infarction	4 hours	None
LiMandri et al[47]	Pericardium	Pericarditis	10 days	Left thoracotomy, extraction
Willemsen et al[55]	Pericardium	Dysrhythmia	12 hours	Extraction
Burkhart et al[59]	Pericardium	Effusion	8 days	Extraction
Tutar et al[61]	LV	Lead toxicity	2 months	None
Seipelt et al[64]	Pericardium	Ischemia (only at site adjacent to missile)	44 years	Extraction, coronary bypass
Elsner et al[65]	LV	Shunt	60 years	Extraction, repair
Wales et al[66]	RV	Dysrhythmia	4 years	Extraction
Le Vecchia et al[67]	RCA	Inferior myocardial infarction	2 hours	None
Actis Dato et al[35]	LA	Dysrhythmia	20 years	Extraction
Bali et al[74]	RCA	Myocardial infarction	48 hours	None
Aubert et al[78]	Pericardium	Valve dysfunction	1 year	Extraction, repair
Ettinger et al[80]	RV	Valve dysfunction	N/A	Extraction, repair

1939 by Decker[81] reported a mortality rate of 30% in 53 patients managed nonoperatively for retained intracardiac foreign bodies. The mortality rate of operative management in his series was 17% with 85% of the 47 patients subjected to surgery having successful localization and extraction of the missile. Although his series included patients who sustained cardiac injury secondary to aerodigestive tract foreign body migration, it led to an aggressive approach to the management of retained cardiac foreign bodies. Additional support was achieved for intervention for retained cardiac foreign bodies when Harken[82] reported a 67% positive microbial culture rate from his series of 56 patients undergoing successful cardiac foreign body removal. There are obvious reported and theoretical early and late complications associated with an RCM (Table 3). The risks of complications must be weighed against the morbidity and mortality of exploration for missile removal. Combined with operative complications, some series report a 30% rate of inability to localize and remove the foreign body.[83]

Symbas et al[1] have published an extensive review of the literature before 1990 pertaining to cardiac missiles as well as their experience in Atlanta with retained cardiac foreign bodies. Their literature review obtained before 1990 provides 222 missiles retained in 201 patients, of which 104 were removed and 118 retained. Most patients in the historical arm sustained trauma during war; had larger, irregular missiles; and were treated during the 1950s and 1960s. Their personal series over 20 years consisted of 24 missiles with removal of 10 and retention of 14. The combined series of patients from the literature and Grady provides 225 total patients with intracardiac missiles. The author's experience at Grady with nonoperative management of 14 cardiac missiles resulted in no complications. The combined series of patients' missile characteristics were scrutinized to allow for subgrouping into categories regarding missile type (bullets, pellets, and unidentified), as well as location within the heart (partial or completely intramyocardial, intrapericardial, or intracavitary). The authors used the nonintramyocardial subgroup (113 total from both series) to help distinguish characteristics that would predict a favorable outcome. Right-sided missiles in this group (n = 76) had a minor and major complication rates of 20% and 4%, respectively. Left-sided missiles had a minor and major complication rate of 27% and 16%, respectively. This difference in complication rates was noted to be statistically significant. The authors concluded that missiles specifically retained within the right heart are safe to manage conservatively unless first contaminated by traversal of a nonsterile organ. This same management strategy was assessed as safe for completely intramyocardial missiles

TABLE 2. Complications by Location in Nonoperatively Managed Patients

Location (Total no.)	Complication (%)
Pericardium (n = 8)	n = 6 (75%)
RCA (n = 4)	n = 3 (75%)
Left heart (n = 8)	n = 4 (50%)
Right heart (n = 16)	n = 2 (13%)
Intramyocardial (n = 7)	n = 0

TABLE 3. Complications (Short Term and Long Term) of Retained Cardiac Missiles

Sepsis: bacteremia, bacterial endocarditis
Conduction defects
Dysrhythmias
Intracardiac shunt
Hemorrhage
Pericardial complications: tamponade, effusion, pericarditis
Embolization (clot/foreign body)
Lead toxicity
Erosion into coronary vessel
Focal atherosclerotic plaque adjacent to retained missile

without symptoms. The authors recommended that all other noncompletely intramyocardial missiles should be removed. Combining our case and literature review with the review by Symbas et al,[1] the following recommendations are made after the diagnosis of an RCM.

LOCALIZATION

Radiographic evidence of blurring of a missile adjacent to or within the cardiac silhouette should increase the suspicion of a missile residing deep to the pericardium.[4] Two-dimensional echocardiography has been reported as the most accurate modality to localize intracardiac bullets.[84] Computed tomography has the advantage of determining missile trajectory and identifying other intrathoracic injuries (hemothorax and pneumothorax).[5] We advocate the use of multiple imaging techniques to include chest radiography, transthoracic and transesophageal echocardiography, computed tomography, and cardiac fluoroscopy. Our patient had an irregular missile that was difficult to localize on computed tomography because of scatter artifact. Echocardiography and cardiac fluoroscopy demonstrated movement with atrial systole and helped ensure no evidence of intracardiac shunt or valvular abnormalities. Scatter was evident on echocardiography and made it impossible to rule out partial protrusion of the missile into the right atrium. If a decision is made to intervene, then every attempt must be made to localize the foreign body precisely because of the historical 30% risk of a negative exploration.[83] We found 2 cases of failed exploration for an RCM since 1990.[49,61] Intraoperative echocardiography[85] and cardiac palpation[22] have been reported as adjuncts for localization.

MANAGEMENT

Based on the limited literature available regarding the subject of RCMs, specific guidelines for their management cannot be made. Exploration with treatment of the cardiac injury is warranted in the patient that presents with hemorrhage, great vessel injury, or tamponade. Missiles with low-risk characteristics (immobile right-sided, smooth, small [<5 mm], or completely intramyocardial) that demonstrate no complications on initial and serial imaging may be managed nonoperatively. Borrowing from vascular trauma terminology, we have organized certain retained cardiac missile characteristics to produce hard and soft indications for their elective intervention with retrieval (Tables 4 and 5).[86] Missiles should be removed if they cause hemodynamically significant effusions or tamponade. This has been reported in a patient 8 days postinjury without symptoms after a direct gunshot wound with retention in the pericardium.[59] Catarino recommends controlled hypotension versus restoration of normotension in patients with RCMs that develop hemopericardium to prevent exacerbation of symptoms with progression to cardiovascular collapse.[25] Elective retrieval for missiles traversing a contaminated organ has also been advocated to prevent septic complications.[6,8,26,43] Irregular missiles such as high-velocity nails and saw-blade fragments (even chicken wire struck by a lawn mower has been reported) should be removed to prevent myocardial damage that can be produced by their shape.[19,21,25,26,34,38,39,41] Wandering intracavitary missiles are apparent on serial imaging and should also be removed to prevent distal embolization of a main pulmonary artery or systemic artery.[3,13,23,31,80] Dysrhythmia, valve dysfunction, or intracardiac shunt caused by the presence of a retained missile and left heart location are also indications for elective retrieval of retained missiles within the heart.[1,7,27,55,65,66,76,78,80] Based on the high risk of complications and ease of retrieval, we placed RCMs within the pericardial sac into the soft indication for retrieval category. Removal of pericardial retained missiles most often requires subxiphoid pericardial window.[27,37,59] Consideration for removal can also be made when the missile is suspicious for providing a source for sepsis.[3,27,33] Cardiac ischemia caused by missile embolization into the right coronary artery has been reported 4 times.[22,46,67,74] Three patients were managed nonoperatively and had an uncomplicated recovery after an inferior myocardial infarction.[46,67,74] Jones reported the extraction of a right coronary artery embolized missile diagnosed intraoperatively during sternotomy for management of an expanding mediastinal hematoma.[22] During the repair of a right subclavian arterial injury, the patient demonstrated ischemic changes on telemetry. Pericardiotomy was performed and palpation revealed the bullet within the right coronary artery. Cardiopulmonary bypass with arteriotomy and extraction was successfully employed. Less inva-

TABLE 4. Hard Indications for Retrieval of Cardiac Missiles

Tamponade/significant pericardial effusions
Entry into heart after contamination[6,8,26,45]
Irregular missile (nail, chicken wire, saw blade fragment)[19,21,25,26,34,36,38,39,45]
Wandering intracardiac missile on serial imaging[3,13,23,31,80]
Intracardiac shunt[27,65]
Posttraumatic dysrhythmia[35,55,66]
Hemodynamically significant valvular abnormality[7,78,80]
Left heart location[1]
Proximity to vital structure (major coronary artery/vein or conduction system) with concern for future complication[49]

TABLE 5. Soft Indications for Retrieval of Cardiac Missiles

Pericardial location: based on historical literature with high complication rate and eases of retrieval[1,88]
Postinjury fevers with concern for missile providing source for sepsis[3,27,33]
Intraoperatively during mediastinal exploration for other indication in setting of accurate localization and minimal expected difficulty in retrieval
Inability to establish long term follow up for serial examination/imaging

sive, endovascular techniques for the management of RCM have also been described. Controlled embolization from the right ventricle into the lower extremity venous system that uses rapid fluoroscopic table repositioning has been successful in 2 cases.[9,13] This technique, termed controlled venous embolization, allows for missile retrieval using an extremity incision and venotomy. Transvenous extraction of right heart missiles using a wire basket or snare is also possible for mobile missiles within the right heart chambers.[23,26,31,43] Cardiac exploration for more complicated retained missiles requires thoracotomy or sternotomy. Intracavitary and intramyocardial retained missiles can be retrieved using off-pump cardiac surgery.[6,14,18,19,28,29] Fedalen[29] has reported successful off-pump missile retrieval using the assistance of a heart stabilization device. More complex injuries with retained cardiac missiles require cardiopulmonary bypass for repair.

FOLLOW-UP RECOMMENDATIONS

Evidence-based guidelines are lacking regarding follow up, need for prophylactic antibiotics, and anticoagulation for RCMs. Patients who present with RCMs may require prolonged hospital stays for recovery from multiple, life-threatening injuries. In the setting of a patient with an isolated injury and an RCM, initial management should include accurate localization and evaluation for an acute complication of an intracardiac missile. We recommend at least 24 hours of telemetry to evaluate for the acute onset of dysrhythmia because of the initial injury or the retained missiles.[70] Serial imaging should be performed before discharge to evaluate for the delayed presentation of a hemodynamically significant pericardial effusion, missile migration, valvular abnormality, or intracardiac shunt. Patients should be counseled before the initial discharge about their diagnosis and the signs and symptoms of complications of RCM. Long-term follow up should be standard and include obtaining a history from the patient of palpitations, fevers, chest pain, anxiety related to the retained missile, or shortness of breath. Physical examination and imaging should also be performed to ensure location stability and to rule out long-term complications from the missile. Some authors recommend anticoagulation until a time that a partially intracavitary missile becomes encapsulated.[69] In 1949, Fritz et al[87] implanted metal foreign bodies in the heart and pericardium of dogs and showed that by 8 weeks, the metal was completely encapsulated by fibrous tissue regardless of location within the myocardium or free within the cardiac chambers. We chose to treat our patient with 3 months of systemic anticoagulation based on the inability to rule out partial intracavitary protrusion of the missile. Some authors recommend prophylactic antibiotics for retained cardiac missiles before dental procedures.[70] Lead toxicity has been reported in 1 case of a shotgun pellet retained in the left ventricle.[61] The time between missile injury/retention and the onset of lead toxicity can be from less than 6 months to decades.[62] The probability of lead poisoning is highest in patients with missiles embedded within a joint or bone.[62] Lead toxicity screening can be considered especially for high-risk patients such as those with multiple retained missiles or missiles with close proximity to bone/joint.[61]

CONCLUSIONS

Cardiac missiles are the result of direct penetration or embolization from an injury from a systemic or pulmonary vessel. Historical recommendations regarding the management of RCM in hemodynamically stable patients suggested prompt extraction. Negative explorations for retained missiles and long-term uncomplicated survival from these unique injuries has led some authors to rethink mandated operative exploration and retrieval. We have reported a case of the successful nonoperative management of an RCM in a patient who sustained injuries secondary to mortar fragments. We performed an updated review of the world literature regarding the subject of RCMs. Including an historical review of this subject by Symbas et al,[1] our review brings the total number of retained cardiac missiles reviewed to 322 patients with RCMs. The management of RCM should be individualized based on thoughtful evaluation and included in this report are recommendations to assist other surgeons caring for injured patients with this uncommon finding.

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